Attorney's Docket No. 708.159A

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

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| Application of: | Valery G. Kagan |
| Serial No.: | Unknown (C-I-P of 09/483,813) |
| Filing Date: | February 26, 2002 |
| Examiner of Parent Appln. 09/483,813): | Scott Kastler |
| Group Art Unit of Parent Appln. 09/483,813): | 1742 |

For: **METHODS EMPLOYING PERMANENT MAGNETS HAVING REACH-OUT MAGNETIC FIELDS FOR ELECTROMAGNETICALLY PUMPING, BRAKING, AND METERING MOLTEN METALS FEEDING INTO METAL CASTING MACHINES (as amended below)**

**PRELIMINARY AMENDMENT TO ACCOMPANY APPLICATION**



Box Patent Application
Commissioner for Patents
Washington, D.C. 20231

SIR:-

This is a Preliminary Amendment to accompany a patent application claiming priority from U.S. Application No. 09/483,813, filed January 15, 2000.

Prior to substantive examination of the above-identified patent application, please amend the application as follows:

CERTIFICATE OF EXPRESS MAILING

I hereby certify under 37 C.F.R. Section 1.10, this Preliminary Amendment is being deposited with the United States Postal Service using "Express Mail Post Office to Addressee" service of the U.S.P.S. and is being mailed with sufficient postage to: Box Patent Application, Commissioner for Patents, Washington, D.C. 20231 on the following date:

February 26, 2002 using Express Mailing Label No. EK091315262US

Beth L. Parmelee

IN THE TITLE:

Please replace the title with the following amended title:

-- METHODS EMPLOYING PERMANENT MAGNETS HAVING REACH-OUT MAGNETIC FIELDS FOR ELECTROMAGNETICALLY PUMPING, BRAKING, AND METERING MOLTEN METALS FEEDING INTO METAL CASTING MACHINES --

IN THE SPECIFICATION:

On Page 1, please delete from line 6 to the end of the page.

Please add the following paragraph after the title:

-- **CROSS REFERENCE TO RELATED APPLICATION**

This application is a continuation-in-part of U.S. patent application Serial No. 09/483,813 filed January 15, 2000, the contents of which are hereby incorporated by reference. --

Please insert the following paragraph at page 32, after the first two full paragraphs and before the last paragraph:

-- ADDENDUM

Controlling flow of molten metal comprising the steps of:

providing a pressurizing conduit having a working area formed of graphite, a fragile material;

protecting said graphite by shrouding it in a jacket formed of suitable rugged material having heat endurance and ability to withstand mechanical shocks and stresses;

and interposing electrically non-conductive material in said jacket positioned around said graphite for isolating the graphite from damage and unwanted piping stresses and from mechanical and electrical shocks and stresses occurring within said jacket.

Controlling flow of molten metal by providing a pressurizing conduit formed of ceramic, a somewhat fragile material.

Protecting said ceramic by shrouding it in a jacket formed of suitable rugged material having heat endurance and ability to withstand mechanical shocks and stresses, and interposing electrically non-conductive material in said jacket positioned around said ceramic for isolating the ceramic from damage and unwanted piping stresses and from mechanical and electrical shocks and stresses occurring within said jacket.

<u>End of ADDENDUM</u> --

<u>IN THE CLAIMS:</u>

Please cancel Claims 2-46 and add new Claims 61 through 84 which read as follows:

61. (New) Apparatus for controlling flow of molten metal comprising:

a conduit formed of non-magnetic material having a passage suitable for controlling flow of molten metal in said passage;

first and second assemblies of neo-magnets positioned on opposite sides of said conduit for providing an intense magnetic field B extending through said passage in a direction generally perpendicular to flow M of molten metal in said passage;

first and second electrodes mounted on opposite sides of said conduit;

said electrodes being positioned for electrically conductive communication with molten metal within said passage;

said first and second electrodes being suitable for connection in an electrical circuit with an electrical source of direct current for providing said first and second electrodes respectively with positive and negative voltage in said electrical circuit for causing electrical direct current I to flow through molten metal in said passage in a direction generally perpendicular to said intense magnetic field B and also generally perpendicular to flow M of molten metal;

said first and second assemblies of neo-magnets including first and second pole pieces of magnetically soft ferromagnetic material respectively positioned on opposite sides of said conduit;

said first pole piece having a pole face oriented generally perpendicular to said magnetic field B and being positioned near and facing toward a first side of said conduit;

said first assembly including a first plurality of neo-magnets positioned with their North poles adjacent to said first pole piece for providing North magnetic polarization of said pole face of said first pole piece;

said second pole piece having a pole face oriented generally perpendicular to said magnetic field B and being positioned near and facing toward a second side of said conduit opposite to said first side thereof;

said second assembly including a second plurality of neo-magnets positioned with their South poles adjacent to said second pole piece for providing South magnetic polarization of said pole face of said second pole piece;

a first enclosure of magnetically soft ferromagnetic material positioned around said first assembly; and

a second enclosure of magnetically soft ferromagnetic material positioned around said second assembly.

62. (New) Apparatus for controlling flow of molten metal comprising:

a conduit formed of non-magnetic material having a passage suitable for controlling flow of molten metal in said passage;

first and second assemblies of neo-magnets positioned on opposite sides of said conduit for providing an intense magnetic field B extending through said passage in a direction generally perpendicular to flow M of molten metal in said passage;

first and second electrodes mounted on opposite sides of said conduit;

said electrodes being positioned for electrically conductive communication with molten metal within said passage;

said first and second electrodes being suitable for connection in an electrical circuit with an electrical source of direct current for providing said first and second electrodes respectively with positive and negative voltage in said electrical circuit for causing electrical direct current I to flow through molten metal in said passage in a direction generally perpendicular to said intense magnetic field B and also generally perpendicular to flow M of molten metal;

said first and second assemblies of neo-magnets including first and second pole pieces of magnetically soft ferromagnetic material respectively positioned on opposite sides of said conduit;

said first pole piece being elongated and being oriented in a direction generally parallel with said direction of flow of direct current I;

said elongated first pole piece also being oriented in a direction generally transverse to said direction of flow M of molten metal;

said elongated first pole piece having an elongated pole face positioned near and facing toward a first side of said conduit and being oriented generally parallel with said

direction of flow of direct current I and also being oriented generally transverse to said direction of flow M of molten metal;

said first assembly including a first plurality of neo-magnets positioned with their North poles adjacent to said elongated first pole piece for providing North magnetic polarization of said elongated pole face of said elongated first pole piece;

said second pole piece being elongated and being oriented in a direction generally parallel with said direction of flow of direct current I;

said elongated second pole piece also being oriented in a direction generally transverse to said direction of flow M of molten metal;

said elongated second pole piece having an elongated pole face positioned near and facing toward a second side of said conduit opposite to said first side thereof and being oriented generally parallel with said direction of flow of direct current I and also being oriented generally transverse to said direction of flow M of molten metal; and

said second assembly including a second plurality of neo-magnets positioned with their South poles adjacent to said elongated second pole piece for providing South magnetic polarization of said elongated pole face of said elongated second pole piece.

63. (New) Apparatus for controlling flow of molten metal claimed in Claim 62,

wherein:

said first assembly includes elongated neo-magnets extending parallel with said elongated first pole piece; and

said second assembly includes elongated neo-magnets extending parallel with said elongated second pole piece.

64. (New) Apparatus for controlling flow of molten metal claimed in Claim 62,

wherein:

said first assembly also includes neo-magnets having North poles adjacent to ends of said elongated first pole piece; and

said second assembly also includes neo-magnets having South poles adjacent to ends of said elongated second pole piece.

65. (New) Apparatus for controlling flow of molten metal comprising:

a conduit formed of non-magnetic material having a passage suitable for controlling flow of molten metal in said passage;

first and second assemblies of neo-magnets positioned on opposite sides of said conduit for providing an intense magnetic field B extending through said passage in a direction generally perpendicular to flow M of molten metal in said passage;

first and second electrodes mounted on opposite sides of said conduit;

said electrodes being positioned for electrically conductive communication with molten metal within said passage;

said first and second electrodes being suitable for connection in an electrical circuit with an electrical source of direct current for providing said first and second electrodes respectively with positive and negative voltage in said electrical circuit for causing electrical direct current I to flow through molten metal in said passage in a direction generally perpendicular to said intense magnetic field B and also generally perpendicular to flow M of molten metal;

first and second neo-magnet assemblies each including eight neo-magnets;

said first and second assemblies being respectively positioned on opposite sides of said conduit;

said first neo-magnet assembly including an inner tier of four neo-magnets having their North poles positioned near and facing toward a first side of said conduit;

said first neo-magnet assembly including an outer tier of four neo-magnets having their North poles positioned adjacent to respective South poles of the four neo-magnets in said inner tier;

said second neo-magnet assembly including an inner tier of four neo-magnets having their South poles positioned near and facing toward a second side of said conduit opposite to said first side thereof;

said second neo-magnet assembly including an outer tier of four neo-magnets having their South poles positioned adjacent to respective North poles of the four neo-magnets in said inner tier;

non-magnetic retainers positioned around said first and second neo-magnet assemblies for holding together said first and second neo-magnet assemblies; and

a frame of magnetically soft ferromagnetic material encircling said first and second neo-magnet assemblies and also encircling said conduit.

66. (New) Apparatus for controlling flow of molten metal claimed in Claim 65,

wherein:

said eight neo-magnets in each of said first and second neo-magnet assemblies are cubical in configuration; and

said first and second neo-magnet assemblies are cubical in overall configuration.

67. (New) Apparatus for controlling flow of molten metal comprising:

a conduit formed of non-magnetic material having a passage suitable for controlling flow of molten metal in said passage;

first and second assemblies of neo-magnets positioned on opposite sides of said conduit for providing an intense magnetic field B extending through said passage in a direction generally perpendicular to flow M of molten metal in said passage;

first and second electrodes mounted on opposite sides of said conduit;

said electrodes being positioned for electrically conductive communication with molten metal within said passage;

said first and second electrodes being suitable for connection in an electrical circuit with an electrical source of direct current for providing said first and second electrodes respectively with positive and negative voltage in said electrical circuit for causing electrical direct current I to flow through molten metal in said passage in a direction generally perpendicular to said intense magnetic field B and also generally perpendicular to flow M of molten metal;

said first and second assemblies of neo-magnets including first and second pole pieces of magnetically soft ferromagnetic material respectively positioned on opposite sides of said conduit;

said first pole piece having a pole face positioned near and facing toward a first side of said conduit;

said second pole piece having a pole face positioned near and facing toward a second side of said conduit opposite to said first side thereof;

said first pole piece having a plurality of surfaces extending from the pole face thereof;

said surfaces of the first pole piece being oriented generally perpendicular to said pole face of said first pole piece;

said first assembly including a plurality of neo-magnets having North poles adjacent to respective surfaces of the first pole piece for providing North magnetic polarity for said pole face of the first pole piece;

said second pole piece having a plurality of surfaces extending from the pole face thereof;

said surfaces of the second pole piece being oriented generally perpendicular to said pole face of the second pole piece; and

said second assembly including a plurality of neo-magnets having South poles adjacent to respective surfaces of the second pole piece for providing South magnetic polarity for said pole face of the second pole piece.

68. (New) Apparatus for controlling flow of molten metal claimed in Claim 67,

wherein:

said first and second pole pieces are equilateral triangular parallelepipeds; and

said first and second assemblies each include three neo-magnets.

69. (New) Apparatus for controlling flow of molten metal claimed in Claim 68,

wherein:

said first and second pole pieces have outer ends configured as equilateral triangles;

said first assembly includes a neo-magnet having an equilateral triangular configuration having a North pole positioned adjacent to the outer end of the first pole piece; and

said second assembly includes a neo-magnet having an equilateral triangular configuration having a South pole positioned adjacent to the outer end of the second pole piece.

70. (New) Apparatus for controlling flow of molten metal claimed in Claim 67,

wherein:

said first and second pole pieces are rectangular parallelepipeds; and

said first and second assemblies each include four neo-magnets.

71. (New) Apparatus for controlling flow of molten metal claimed in Claim 67,

wherein:

said first and second pole pieces are square parallelepipeds; and

said first and second assemblies each include four neo-magnets.

72. (New) Apparatus for controlling flow of molten metal claimed in Claim 71,

wherein:

said first and second pole pieces have square outer ends;

said first assembly includes a neo-magnet having a square North pole adjacent to the square outer end of the first pole piece; and

said second assembly includes a neo-magnet having a square South pole adjacent to the square outer end of the second pole piece.

73. (New) Apparatus for controlling flow of molten metal claimed in Claim 67,

wherein:

said first and second pole pieces are hexagonal in cross section; and

said first and second assemblies each include six neo-magnets.

74. (New) Apparatus for controlling flow of molten metal claimed in Claim 73,

wherein:

said first and second pole pieces have hexagonal outer ends;

said first assembly includes a neo-magnet having a hexagonal North pole adjacent to the hexagonal outer end of the first pole piece; and

said second assembly includes a neo-magnet having a hexagonal South pole adjacent to the hexagonal outer end of the second pole piece.

75. (New) Apparatus for controlling flow of molten metal comprising:

a conduit formed of non-magnetic material having a passage suitable for controlling flow of molten metal in said passage;

first and second neo-magnets positioned on opposite sides of said conduit for providing an intense magnetic field B extending through said passage in a direction generally perpendicular to flow M of molten metal in said passage;

first and second electrodes mounted on opposite sides of said conduit;

said electrodes being positioned for electrically conductive communication with molten metal within said passage;

said first and second electrodes being suitable for connection in an electrical circuit with an electrical source of direct current for providing said first and second electrodes respectively with positive and negative voltage in said electrical circuit for causing electrical direct current I to flow through molten metal in said passage in a direction generally perpendicular to said intense magnetic field B and also generally perpendicular to flow M of molten metal;

said first and second assemblies of neo-magnets including first and second pole pieces of magnetically soft ferromagnetic material respectively positioned on opposite sides of said conduit;

said first and second pole pieces being circular cylindrical; and

said first and second neo-magnets being annular rings respectively encircling the first and second circular cylindrical pole pieces;

said first neo-magnet being magnetized in a direction through its radial thickness and having an inner North pole adjacent to the first circular cylindrical pole piece; and

said second neo-magnet being magnetized in a direction through its radial thickness and having an inner South pole adjacent to the second circular cylindrical pole piece.

76. (New) Apparatus for controlling flow of molten metal claimed in Claim 75,

wherein:

said first and second pole pieces have circular outer ends;

a circular neo-magnet has a North pole adjacent to the circular outer end of the first pole piece; and

another circular neo-magnet has a South pole adjacent to the circular outer end of the second pole piece.

77. (New) A method for controlling flow of molten metal comprising steps of:

providing a pressurizing conduit formed of non-magnetic material;

providing said pressurizing conduit having a generally constant height and a generally constant width throughout the working area of said pressurizing conduit;

said width being greater than said height;

positioning at least one neo-magnet above said working area;

positioning at least one neo-magnet below said working area;

said neo-magnet positioned above said working area having its north polarity pole face oriented in a magnetic circuit B for directing its magnetic flux through said working area;

said neo-magnet positioned below said working area having its south polarity pole face oriented in said magnetic circuit B for directing its magnetic flux through said working area in additive relationship relative to the magnetic flux of said neo-magnet positioned above said working area of said pressurizing conduit;

positioning a DC electrode having positive electrical potential on one side of said working area of said pressurizing conduit;

positioning a DC electrode having negative electrical potential on the opposite side of said working area of said pressurizing conduit from said DC electrode having positive electrical potential; and

said electrodes being positioned for electrical conductive communication with molten metal M within said working area of the pressurizing conduit.

78. (New) Apparatus for controlling flow of molten metal claimed in Claim 77, wherein:

said electrodes have a greater length in electrical conductive communication with molten metal M in the direction of flow of said molten metal M than their height in electrical conductive communication with molten metal M in the direction of magnetic flux passing through said molten metal M.

79. (New) A method for controlling flow of molten metal comprising:

mounting said electrodes in electrically non-conductive electrode holders seated within opposite walls of the working area of the pressurizing conduit with portions of the electrodes being exposed to electrically conductive communication to molten metal in the working area of the pressurizing conduit.

80. (New) A method for controlling flow of molten metal claimed in Claim 79, wherein:

said electrode holders are seated within exterior portions of the wall of the pressurizing conduit; and

each of said electrodes has a portion which protrudes inwardly from its electrode holder into electrically conductive communication with molten metal M within the working area of the pressurizing conduit.

81. (New) A method for controlling flow of molten metal comprising steps of:

providing a pair of elongated neo-magnets of equal length each having elongated magnetically polarized pole faces extending for the length of the neo-magnet;

positioning said elongated neo-magnets in vertically spaced parallel relationship with one of said elongated neo-magnets being positioned above a working area of a pressurizing conduit and the other of said elongated neo-magnets being positioned below said working area of the pressurizing conduit;

orienting the magnetically polarized pole faces of the elongated neo-magnets for directing their magnetic flux in magnetically additive relation in a magnetic flux circuit B passing through the working area of the pressurizing conduit; and

positioning said elongated neo-magnets with their length extending generally perpendicular to flow of molten metal within the working area of the pressurizing conduit, thereby providing a molten metal pump having a pressurizing passage with a flow width more than ten times greater than its height.

82. (New) A method for controlling flow of molten metal comprising steps of:

providing a pressurizing conduit formed of non-magnetic material;

providing said pressurizing conduit having a generally constant height and a generally constant width throughout the working area of said pressurizing conduit;

said width being greater than said height;

positioning at least one neo-magnet above said working area;

positioning at least one neo-magnet below said working area;

said neo-magnet positioned above said working area having its north polarity pole face oriented in a magnetic circuit B for directing its magnetic flux through said working area;

said neo-magnet positioned below said working area having its south polarity pole face oriented in said magnetic circuit B for directing its magnetic flux through said working area in additive relationship relative to the magnetic flux of said neo-magnet positioned above said working area of said pressurizing conduit;

positioning a DC electrode having positive electrical potential on one side of said working area of said pressurizing conduit;

positioning a DC electrode having negative electrical potential on the opposite side of said working area of said pressurizing conduit from said DC electrode having positive electrical potential;

said electrodes being positioned for electrical conductive communication with molten metal M within said working area of the pressurizing conduit;

positioning four flow-sensing electrodes in electrically conductive communication with molten metal M within said working area of the pressurizing conduit;

two of said flow-sensing electrodes being positioned upstream relative to the flow of molten metal M within said working area;

two of said flow-sensing electrodes being positioned downstream relative to the flow of molten metal M within said working area;

said flow-sensing electrodes being symmetrically positioned upstream and downstream relative to the flow of molten metal M in said working area and also being symmetrically positioned left and right relative to the flow of molten metal M in said working area; and

combining and averaging electrical outputs from said sensing electrodes for cancelling undesired e.m.f.s to not distort the generated and combined control e.m.f. to be fed into a meter or control for D.C. current I being fed through molten metal M within said working area of the pressurizing conduit.

83. (New) Controlling flow of molten metal comprising the steps of:

providing a pressurizing conduit formed of graphite, a fragile material;

protecting said graphite by shrouding it in a jacket formed of suitable rugged material having heat endurance and ability to withstand mechanical and electrical shocks and stresses; and

interposing electrically non-conductive material in said jacket positioned for isolating said graphite from damage and from unwanted piping stresses and from mechanical and electrical shocks and stresses occurring in said jacket.

84. (New) Controlling flow of molten metal comprising the steps of:

providing a pressurizing conduit formed of ceramic;

protecting said ceramic by shrouding it in a jacket formed of suitable rugged material having heat endurance and ability to withstand mechanical and electrical shocks and stresses; and

interposing electrically non-conductive material in said jacket positioned for isolating said ceramic from damage and from unwanted piping stresses and from mechanical and electrical shocks and stresses occurring in said jacket.

IN THE ABSTRACT:

Please replace the Abstract with the following amended Abstract.

Method precisely, quickly controls flow of molten metal to metal-casting apparatus by pumping, braking or throttling. The Faraday-Ampère principle of current flow in a unidirectional magnetic field is employed. Permanent magnets comprising neodymium or similar high-energy, rare-earth materials provide "reach-out" magnetism. These neo-magnets, usually shown as

cubes, are arranged in various powerful configurations driving intense unidirectional magnetic field B across a non-magnetic gap many times larger than economically feasible otherwise. This gap accommodates a conduit for pressurizing and moving a flow of molten metal. In making multiple identical castings, a controlled, intermittent, predetermined flow of molten metal is fed to a series of identical individual molds. The invention obviates needs for operating metallurgical valves or expensive tilting mechanisms for metallurgical furnaces. Existing furnaces too low to permit inflow by gravity may be rendered usable by embodiments of this invention.

## REMARKS

The present application is a continuation-in-part of co-pending application Serial No. 09/483,813, filed January 15, 2000. Applicant has amended the application to include a cross-reference to the co-pending parent application. Applicant has cancelled Claims 2-46, and added new Claims 61-76. Original Claim 1 has been retained to ensure co-pendency. Favorable consideration of the accompanying patent application is courteously solicited.

Respectfully submitted,

Dated: February 26, 2002 By G. Kendall Parmelee

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Docket 708.159A

## VERSION WITH MARKINGS SHOWING CHANGES MADE

IN THE TITLE:

Methods[, System and Apparatus] Employing Permanent Magnets Having Reach-Out Magnetic Fields for Electromagnetically [Transferring] Pumping, Braking, and Metering Molten Metals Feeding into Metal Casting Machines

IN THE SPECIFICATION:

Please see the following page with markings showing changes made to the first page of the Specification.

# METHODS [, SYSTEM AND APPARATUS] EMPLOYING PERMANENT MAGNETS HAVING REACH-OUT MAGNETIC FIELDS FOR ELECTROMAGNETICALLY [TRANSFERRING] PUMPING, BRAKING, AND METERING MOLTEN METALS FEEDING INTO METAL CASTING MACHINES

[Inventor: Valery G. Kagan
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## OTHER PUBLICATIONS

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Douglas W. Dietrich, "Magnetically Soft Materials," Metals Handbook, 10th edition, Volume 2 (1990) pp. 761-781.

D. A. Watt, "The Design of Electromagnetic Pumps for Liquid Metals", Proceedings of the Institution of Electrical Engineers, Volume 106 (December 1958) pp. 94-103.

Lester R. Moskowitz, Permanent Magnet Design and Application Handbook, reprint edition (Malabar, Florida: Krieger Publishing Co., 1986).]

IN THE ABSTRACT:

[Apparatus, system and m] Method [for] precisely, [and] quickly control[ling the]s flow of molten metal to metal-casting apparatus[, either] by pumping, [or by] braking or throttling. The Faraday-Ampère [electromagnetic] principle of current flow in a unidirectional magnetic field is employed[, wherein Faraday's three-finger rule shows pumping direction or throttling direction]. Permanent magnets comprising neodymium or similar high-energy, rare-earth materials provide [a unique] "reach-out" magnetism. These neo-magnets, usually shown as cubes, are arranged in various powerful configurations [for] driving [an] intense unidirectional magnetic field B across a non-magnetic gap many times larger than [is] economically feasible otherwise. This gap accommodates a conduit for pressurizing and moving a flow of molten metal. [Molten metal may be pumped to a distributor or a siphon at an entrance to a metal-casting machine. Alternatively, an unconstrained parabolic jet-fountain-stream of molten metal is projected through an inert atmosphere directly into such a machine, thereby avoiding need for long passageways containing fragile refractories for channelling molten metal flows.] In making multiple identical castings, [the invention enables] a controlled, intermittent, predetermined flow of molten metal is [to be] fed to a series of identical individual molds. [Among its advantages are that t] The invention obviates needs for [servo-]operating metallurgical valves or expensive tilting mechanisms for metallurgical furnaces. Existing furnaces [which are] too low to permit inflow by gravity [to a point of casting] may be rendered usable by embodiments of this invention.